THE COEFFICIENT OF PERSISTENCE

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In connection with Besson's note on the probability of rain,[6] following one or more days of rain, at Paris, similar tables and calculations may be of interest for an interior station of the United States, as showing the difference in the rainfall régimes in different climatic regions, and as affording a test of the value of his coefficient of persistence.

Three tables prepared in the same way as those of Besson are here presented for Lincoln, Nebr., for the 30-year period, 1894–1923. All traces of precipitation are included in the reckoning, as appears to be the case in Besson's tables. A fourth table is added in which only days with 0.01 inch or more of precipitation are counted. The total number of days of observation is 10,956, and the total number of rainy days, including traces, is 4,312, making the general probability, 0.394.

TABLE 1.—*Number of groups, S, of k consecutive days of rain*

k	1	2	3	4	5	6	7	8
S (observed)	863	588	234	138	76	31	23	10
S (calculated)	1,586	627	247	97	38	15	6	2

k	0	10	11	12	13	14	15	16
S (observed)	8	4	4	2	0	0	0	2
S (calculated)	0.8	0.3	0.1	0.04	0.02	0.01	0.004	0.002

TABLE 2.—*Probability, p_k, of rain when it is known to have rained the k preceding days*

k	1	2	3	4	5	6	7	8	9	10	11
p_k	0.54	0.52	0.56	0.56	0.58	0.62	0.61	0.61	0.64	0.62	0.60

TABLE 3.—*Monthly and annual values of the coefficient of persistence, R*

	J	F	M	A	M	J	J	A	S	O	N	D	Year
p	0.37	0.38	0.37	0.48	0.49	0.50	0.42	0.42	0.38	0.33	0.29	0.30	0.394
p_1	.52	.56	.52	.60	.60	.59	.50	.46	.53	.54	.52	.31	.540
R	.24	.29	.24	.23	.22	.18	.14	.07	.24	.31	.32	.30	.241

[6] MONTHLY WEATHER REVIEW, June 1924, 50: 308.

TABLE 4.—*Monthly and annual values of the coefficient of persistence, R, traces omitted*

	J	F	M	A	M	J	J	A	S	O	N	D	Year
p	0.17	0.19	0.22	0.31	0.37	0.37	0.27	0.29	0.28	0.21	0.16	0.18	0.252
p_1	.33	.43	.34	.47	.51	.44	.35	.36	.48	.45	.41	.39	.421
R	.19	.30	.15	.23	.22	.11	.11	.10	.28	.30	.30	.26	.226

There are no such long rainy periods at Lincoln as at Paris, but Table 1 shows the same general characteristics, with the first three groups decreasingly less numerous than indicated by the law of probability, and the others increasingly more numerous. The effective probabilities of rain following one or more days of rain, as shown in Table 2, are not so great as those at Paris, but show a similar trend and a similar relation to the general probability. At Paris p_1 is 134 per cent of p, and at Lincoln it is 137 per cent.

The cœfficients of persistence, as set out in Table 3, show the contrast in the character of the rain at the two cities. The annual cœfficient, 0.24, at Lincoln is only 63 per cent of that at Paris, and perhaps gives a fair indication of the general difference between the two places in the persistence of rain, but there is a further difference shown in the monthly values. In the months of June, July, and August, when practically all the rain falls in thundershowers, the probability of rain after one day of rain is very little greater than the general probability, especially in August, but in the fall and early winter months there is a definite and marked increase in the cœfficient, while from January to May[7] the rains are more persistent than the midsummer rains but less so than the autumn rains. By omitting traces, as in Table 4, the probabilities are reduced but the cœfficients are not much altered. In each case the difference in type between the summer and autumn precipitation is distinctly shown.

This simple mathematical expression, the cœfficient of persistence, thus appears to offer a valuable and definite means of characterizing one aspect of rainfall, but it is evident that the use of a single annual cœfficient is less valuable at Lincoln that at Paris. It is, in fact, entirely inadequate at Lincoln, and monthly or seasonal cœfficients must be used.

[7] Mostly cyclonic rains occur in these months.—*Ed.*

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SIR NAPIER SHAW, F. R. S.

If the Earth Went Dry

The phenomena of the general circulation of the atmosphere depend fundamentally upon warming at the surface by the sun's rays and on cooling these [?] by outward radiation; but the dominant factor of weather is the modification due to water vapor in the air. In this paper, in order to clear ideas, the reader is invited to regard these two aspects of thermal influence as distinct, and to consider the effect of dry heat alone. We thus form an idea of what the general circulation would be if there were no water vapor at all in the air.

The subject is hypothetical, inasmuch as the actual circulation is generally affected by the condensation or evaporation of water, but its discussion is not necessarily sterile. It is an exercise in some important points of thermal economy; in deserts the conditions postulated are approximately realized, and yet winds, dust storms, and "dust-devils" are not infrequent there; and in the large part of the atmosphere where the temperature is below 270 t the relative amount of water vapor, though not by any means without function, is too small to play the dominant rôle.

It is assumed that "dry" air (except for dust) would be perfectly transparent. Radiation received by a perfect absorber normal to the sun's rays would be 135 kilowatts per square dekameter (subject to small variations of the solar constant), and the loss of heat from a surface radiating perfectly (subject to local variation on account of dust) would be $.572 \times (t/100)^4$ kw., and range from 9 kilowatts per (10 meter)^2 for 200 t to 46 for 300 t. A table is given of the temperatures (between 200 t and 402 t) at which the loss from a radiating surface would balance the income for given solar altitudes.

The technical discussion is in five sections:

1. A survey of the thermal processes operative in the absence of water vapor: (*a*) The katabatic effect of inclined surfaces cooling in the polar night; (*b*) the slow thermal convection, upward, by the building up of layers of dry air in convective equilibrium over flat solarized surfaces (incidentally the question of superheated air

is dealt with); and (c) the mixing of superposed layers by eddy-motion.

2. An estimate of the flow of air necessary to keep a steady state of temperature on a polar slope under assumed conditions during prolonged nocturnal radiation. A possible value of 300 km. per hour offers a justification for the use of the term "dust blizzard" as descriptive of the weather.

3. An estimate of 2 km. as the probable daily height of a layer in convective equilibrium under a tropical sun.

4. Diagrammatic sections of surfaces of equal temperature and of equal potencial temperature for sunrise and sunset at solstice and equinox. A permanent stratosphere, nibbled daily by a convective troposphere, is presupposed for the purpose of estimating its probable temperature, which is near 300 *t*. The incidental curiosities of temperature are set out.

5. The pressure and winds consequent upon the temperature are sketched, with the conclusion that a polar front would still be operative and a general circulation not dissimilar in some of its main factors from the present form.

SIR FREDERIC STUPART.—*The Variableness of Canadian Winters*

In normal seasons North Pacific cyclonic areas usually move south-eastward, with their centres well off the coast until at about the latitude of Northern British Columbia they enter the continent, while anticyclonic conditions of moderate intensity with low temperature prevail in Yukon and the Mackenzie River.

In certain years, however, the Pacific cyclonic areas are less intense and enter the continent further south, while great anticyclonic developments occur in the far north and sweep south-eastward over Canada, accompanied by severe cold waves, which not infrequently reach the Atlantic coast. These conditions lead to abnormally cold winters in Canada.

In other years the North Pacific cyclonic areas appear to be of such intensity that they force their way into the continent in high latitudes and actually prevent the formation of anticyclones and their concomitant low temperature. These conditions lead to mild winters in Canada.

The Meteorological Service is investigating as to whether there is any connection between the temperature and position of the Japan current and the behavior of these cyclonic areas.

F. J. W. WHIPPLE.—*The Diurnal Variation of Pressure: Facts and Theories*

The regular oscillation of pressure shows remarkable regularities all over the globe, and it is, therefore, probable that it is connected in a simple way with its cause. The object of this paper is to emphasise the fact that there is an opening here for speculation as well as for more analysis of the records. The preparation of critical tables of pressure at places where barographs have been maintained for long periods requires international co-operation. Observational material is exceptionally rich in the British Isles, where a number of photographic barographs properly compensated for temperature changes and with open time-scales have been in operation for more than fifty years. The British records indicate that the average diurnal variation of pressure for a given time of year can be regarded as due to the combination of a local wave (a pure sine-curve) and a planetary wave. The planetary wave is not a pure sine curve; the changes in its form conform closely to changes in the sun's declination. It is pointed out that these facts are difficult to reconcile with Lord Kelvin's resonance hypothesis, and in conclusion other objections to that hypothesis are also mentioned.

PROF. W. J. HUMPHREYS.—*The Relation of Wind to Height*

On the average, perhaps, and especially on the equatorial side of cyclones, the wind varies as follows with height: Increases rapidly, but decreasingly so, with height up to 400 to 500 metres above the surface; then decreases slightly through, say, 300 metres; after this increases a little, and then remains, roughly, constant up to round 2,000 to 3,000 metres above the surface; here again often slightly decreases; and then through the next several kilometres increases in proportion to decrease of density. Directions of the wind and its temperature also are interestingly related to height above the surface.

All these observed facts are plausibly explained as effects of mechanical and thermal turbulence.

J. BJERKNES.—*The Importance of Atmospheric Discontinuities for Practical and Theoretical Weather Forecasting*

Empiric investigations show that new-formed depressions usually consist of two oppositely directed air currents, the one warm and the other cold. Initially each current occupies about one-half of the region covered by the depression. The area of the cold air is, however, always increasing, and finally it embraces the whole of the depression in the lower layers. The warm air covers at the ground a correspondingly decreasing space (the warm sector). During the development of the depression, air from the warm sector will escape upwards and spread in higher layers. This motion involves a transformation from potential into kinetic energy (strengthening of the wind and deepening of the depression). The kinetic energy of the depression decreases again as soon as there is merely cold air supply available for the ascending motion. The temperature distribution in the depression thus gives useful indications concerning the expected development.

The result may be formulated mathematically as an equation giving the acceleration of the different air masses relatively to each other. One may thus, at least theoretically, arrive at a mathematical forecast, provided that sufficient observational data are at hand. This is exemplified in a depression passing Central Europe on February 1, 1923.

L. F. RICHARDSON.—*Turbulence and Temperature-gradient among Trees*

The writer has previously derived from theory a criterion for the increase of turbulence, applicable at a height in the free air great compared with the irregularities of the ground. By contrast the present investigation relates to observations made among trees. The temperature gradient was measured by a pair of thermo-junctions placed at different heights. This is compared with the gustiness as shown by a Dines pressure-tube anemometer.

Dr. J. S. OWEN.—*The Automatic Measurement of Atmospheric Pollution*

Refers especially to results of the automatic recorder designed by the author for the Advisory Committee on Atmospheric Pollution. The function of this is to measure the pollution of city air by smoke. A short description and references to fuller descriptions are given. The results obtained in London by this apparatus are compared with those of the author's dust counter (*Proc. Roy. Soc. A.*, Vol. 101, 1922) and show a good correspondence. Curves obtained by both methods in investigating the effect of suspended matter on obstruction of light are given; the relation between obstruction and dust content is shown to be nearly a straight-line one. From this comparison it appears that 1 milligramme of dust per cubic metre has the same effect as about 10,000 particles per cubic centimetre; thus 10^{10} smoke particles weigh 1 mg. approximately. The size of suspended dust particles is fairly uniform, but tends to increase during smoke fogs, probably due to their rapid formation giving insufficient time for grading by settlement.

J. PATTERSON.—*Upper-Air Observations in Canada*

Upper air observations were commenced in Canada in 1911, but were partially interrupted by the war. It has not yet been possible to get balloons for carrying instruments equal to those of pre-war days; there are, however, good prospects of overcoming this handicap in the near future. During the past year an automatic apparatus for calibrating the meteorographs has been installed and the Dines meteorograph simplified. The results of the sounding balloon ascents during the past five years and the observations with pilot balloons in the Arctic will be discussed, together with the prospects of permanently extending the field of observations in the upper air to this region.

PROF. H. H. KIMBALL.—*The Determination of Daylight Intensity from Automatic Records of Total Solar and Sky Radiation*

Colour temperatures of sunlight and skylight, and the spectrum energy curves of radiation from the sun and from the sky have been utilised to determine approximately the spectrum energy curve of the total radiation received on a horizontal surface, and its variation with atmospheric transmissibility and the solar zenith distance.

A comparison of these latter curves with the curve of "visibility of radiation" permits a prediction to be made of the variations to be expected in the ratio between the intensities of the vertical components of daylight and of the total solar and sky radiation.

This ratio has also been determined experimentally by comparing photo metric measurements of daylight illumination on a horizontal surface with continuous records of the total solar and sky radiation made by a U. S. Weather Bureau thermoelectric pyrheliometer horizontally exposed.

The above investigations have been confined to skies that were either cloudless or else completely covered with clouds.

PROF. W. J. HUMPHREYS.—*Rainmaking*

Several of the more persistently urged schemes for producing rain are considered in respect to the underlying principles involved, and measured quantitatively to determine the question of their practical use.

These schemes include, especially, the production of loud noises; the use of chemicals; mechanical or forced convection; fog-collecting screens; dusting the sky; spraying liquid air on to clouds; and sprinkling clouds with electrified sand.

None of these rainmaking methods is practicable in the commercial sense of the term; but each, when treated quantitatively, is full of meteorological interest.